OPERATION
&
MAINTENANCE
MANUAL
MODEL 600
Vibration Analyzer

p34

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OPERATION AND MAINTENANCE MANUAL

VIBRATION ANALYZER MODEL 600

IRD MECHANALYSIS, INC.
SUBSIDIARY OF H. H. ROBERTSON COMPANY
6150 HUNTLEY ROAD, COLUMBUS, OHIO 43229
PHONE: 614/885-5376 • TELEX: 24 5318 • CABLE ADDRESS: IRDMECH, USA

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IRD #194D–853A–297C
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International Research and Development Corporation is making available to industry electronic tools for practical and economical solutions of vibration and balancing problems. Our engineering and research departments are constantly developing new tools and instruments to solve other industrial problems through the science of electronics, though problems of dynamic balance, vibration elimination, and vibration monitoring, in industry are our first concerns.

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CONTENTS

Page No.

OPERATION MANUAL (I R D #194D)

Introduction 1

Description 2

Operation 6

In-Place Balancing 18

Preliminary Performance Checks And Calibration Instructions (I R D #853A)

Appendix A

GENERAL PERFORMANCE SPECIFICATIONS (IRD #297A)

Appendix B

IRD

MODEL 600
Vibration Analyzer

INTRODUCTION

IRD Model 600 Vibration Analyzer constitutes a rugged, accurate and reliable instrument designed to perform three basic functions, namely to detect and measure vibration, to pinpoint the cause, and to aid in correcting imbalance, either in-place, or in conjunction with a machine assembly constituting a balancing machine. Furthermore, this instrument affords the versatility, sensitivity, and simplicity of operation required to solve vibration problems of a wide variety.

DESCRIPTION

Model 600 Vibration Analyzer affords the three parameters required to analyze a vibration, namely displacement or velocity, frequency and phase. Therefore, the instrument includes a displacement-velocity amplitude meter, a frequency meter, a vibration pickup, and a stroboscopic lamp. A broad or sharp tuning, variable electronic filter is included to increase the flexibility of the instrument. The associated controls appearing on the front panel are a displacement-velocity selector, an amplitude range selector, a broad/sharp filter or oscillator selector, a filter tuner, and a frequency range selector.

The general specifications of the instrument are:

Size:	10" high x 15-1/4" x 18"
Weight:	39 lbs. with accessories
Power requirements:	105 to 130 volts, 60 cycles, 2 or 3 wire, 75 watts

The major components included in the standard unit are:

Quantity	IRD Model No.	or	IRD Part No.	Description
1	600			Instrument console
1	544		4526	Vibration pickup
1	566		4241	Stroboscopic light
1			1103	Straight probe
1			3875	Strob cable (12 feet)
1			2484	Pickup cable (12 feet)
1			2914	Power cable with adapter (8 feet)

The amplitude meter registers selectively the integrated or the non-integrated velocity signal transmitted by the vibration pickup. The amplitude of the vibration displacement is presented in terms of peak-to-peak displacement. Velocity is presented in terms of maximum velocity. The face of the meter is divided into two scales, the top scale being graduated from 0 to 1 by ten increments, the lower scale being graduated from 0 to 3 by three increments. The range selector permits the use of four ranges for the top scale, and three ranges for the lower scale.

These ranges are:

Displacement:

.1 = 0 to 0.1 mil peak-to-peak displacement full scale;

.3 = 0 to 0.3 mil peak-to-peak displacement full scale;

1. = 0 to 1.0 mil peak-to-peak displacement full scale;

3. = 0 to 3.0 mils peak-to-peak displacement full scale;

10. = 0 to 10. mils peak-to-peak displacement full scale;

30. = 0 to 30.0 mils peak-to-peak displacement full scale;

100. = 0 to 100.0 mils peak-to-peak displacement full scale.

One mil equals one thousandth of one inch.

Velocity:

.03 = 0 to .03 in/sec maximum velocity full scale;

.1 = 0 to .1 in/sec maximum velocity full scale;

.3 = 0 to .3 in/sec maximum velocity full scale;

1. = 0 to 1.0 in/sec maximum velocity full scale;

3. = 0 to 3.0 in/sec maximum velocity full scale;

10. = 0 to 10.0 in/sec maximum velocity full scale;

30. = 0 to 30.0 in/sec maximum velocity full scale.

The frequency meter indicates the number of times per minute that the system under study is vibrating. This meter has two scales to facilitate the readings, the top scale being white and the lower scale being yellow. To change the range of the frequency range selector which has white ranges corresponding to the top scale on the meter, and yellow ranges corresponding to the lower scale.

These ranges are:

1.5 = 0 to 1500 cycles per minute (white, top scale)

5. = 0 to 5000 cycles per minute (yellow, lower scale)

15. = 0 to 15,000 cycles per minute (white, top scale)

50. = 0 to 50,000 cycles per minute (yellow, lower scale)

150. = 0 to 150,000 cycles per minute (white, top scale)

The broad or sharp continuously variable filter broadens the versatility of this instrument. It simplifies complex vibration and balance problems on assembled machines by filtering all frequencies other than that to which it is tuned. The dial of the filter is divided: the top scale is white, and the lower scale is yellow, corresponding to the color coding of the frequency range selector and the frequency meter (the frequency range selector applies to the filter as well as the frequency meter).

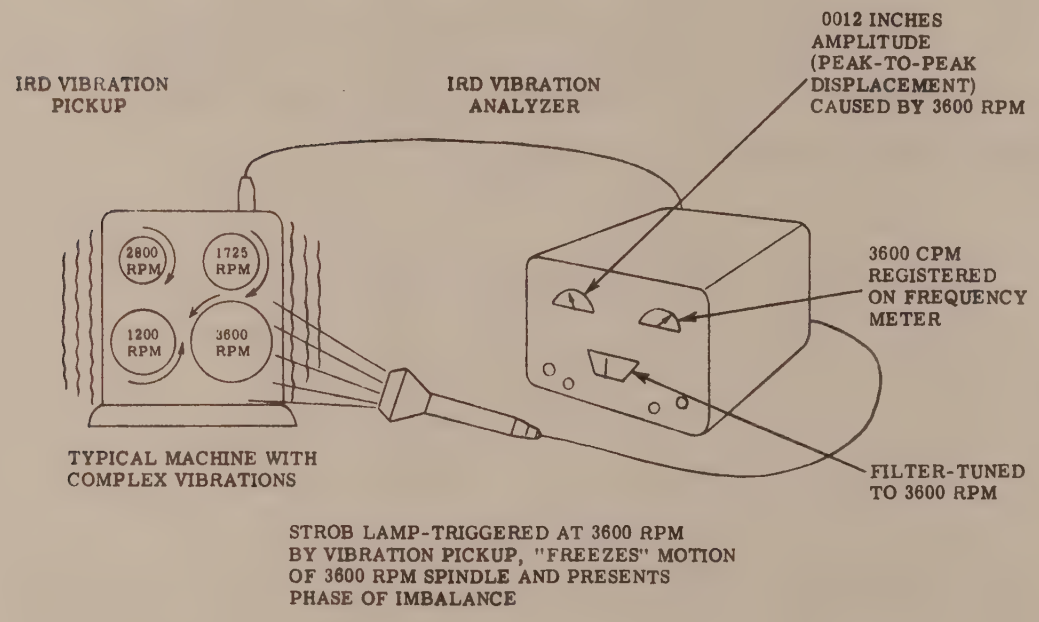
IRD VIBRATION PICKUP
IRD VIBRATION ANALYZER
0012 INCHES AMPLITUDE (PEAK-TO-PEAK DISPLACEMENT) CAUSED BY 3600 RPM
2800 RPM
1725 RPM
1200 RPM
3600 RPM
3600 CPM REGISTERED ON FREQUENCY METER
TYPICAL MACHINE WITH COMPLEX VIBRATIONS
FILTER-TUNED TO 3600 RPM
STROB LAMP-TRIGGERED AT 3600 RPM BY VIBRATION PICKUP, "FREEZES" MOTION OF 3600 RPM SPINDLE AND PRESENTS PHASE OF IMBALANCE

Figure 1 - Illustration showing how variable filter is tuned to one component only.

The vibration pickup (inductive velocity type, IRD Model 544) is a rugged unit designed to withstand the rigors of industrial usage without impairment to calibration or sensitivity. The pickup responds only to vibration in the direction of the probe (transverse response is less than 5% from 10 to 1,000 cps). A 12-foot pickup cable is provided with each unit (longer lengths are available). A detachable extension probe is also provided with the pickup.

The specifications of the vibration pickup are:

Dimensions:

2-3/16" diameter by 4-1/2" length (including connector)

Threads for the extension probe:	1/4-28 x 1/4 N.F.
Weight:	22 ounces
Temperature range:	-40° F. to + 500° F. case temperature
Sensitivity:	Velocity: 1.08 volts peak per inch per second. Displacement: 240 millivolts RMS ±10% for a .001 inch peak-to-peak displacement at 100 cps.
Natural Resonant Frequency:	16 cps critically damped at +77° F.

Longer pickup cables are available as follows:

Length	IRD Part No.
25 feet	2485
50 feet	2486
75 feet	2487
100 feet	2488

The stroboscopic lamp is housed in an electric lantern type case. A positive ON or OFF switch is incorporated in the handle. The stroboscopic bulb IRD Part No. 1383 may be replaced by removing the front of the case. Although the stroboscopic lamp is normally triggered by the vibration (for purposes of measuring relative phase of vibration caused by imbalance in a rotating component, and for locating the cause of vibration), it can also be manually controlled through a range of 450 to 5,000 flashes per minute. The controls used for the filter are also used for manual strob control, but only the 1.5 and 5. ranges are used to indicate the flash rate.

A scope jack and recorder jack are provided at the rear of the instrument; the first permits the visual study of the vibration waveform; the latter permits the graphic study of the vibration. The signal from the scope jack should be connected into a high impedance amplifier with an input impedance of at least one megohm; the scope jack provides an AC signal equivalent to approximately 17 volts RMS at full scale indication on the amplitude meter.

The signal from the recorder jack should be connected to a recorder through a preamplifier with an input impedance of at least 50,000 ohms; the recorder jack pro-

vides a DC signal equivalent to approximately 1 volt at full scale indication on the amplitude meter.

A 117 volt, 60 cycle, 2 wire accessory outlet is available at the rear of the console for operation of supplementary equipment.

OPERATION

The IRD Model 600 Vibration Analyzer is designed to measure the peak-to-peak displacement and maximum velocity of vibration and pinpoint the source. When imbalance is the cause, it serves to balance the rotating parts in-place, without costly dismantling of machinery. The instrument also serves as the electronic brain of dynamic balancing systems used in plant maintenance and production for dynamic balancing of components prior to assembly.

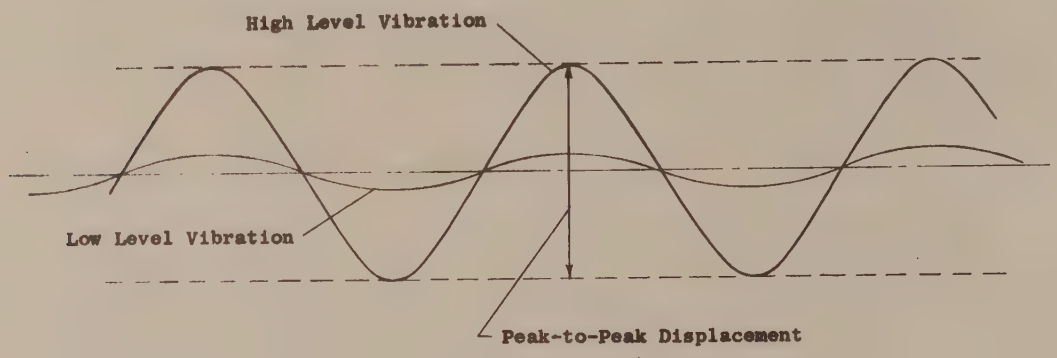

Figure 2–Vibration Waveforms

The basic principle of the electronic operation of this instrument is as follows:

> The vibration pickup transforms the mechanical vibration being observed into a corresponding electrical signal whose voltage is directly proportional to the amplitude of the vibration. This signal is then amplified in the electronic circuit and registered on the amplitude meter and on the frequency meter. The variable filter, when used, eliminates all other frequencies of vibration except that to which it is tuned. The signal from the pickup also normally triggers the stroboscopic lamp in synchronization with the frequency of the vibration (an internal oscillator is also incorporated with which the flash rate of the lamp can be manually controlled if desired).

To prepare the Vibration Analyzer for operation, follow these steps:

Step 1 - Connect the power cable to a 117V, 60 cycle outlet and to the receptacle at the rear of the instrument.

Step 2 - Screw the probe to the pickup and connect the pickup to the console by means of the cable provided.

Step 3 - Connect the stroboscopic lamp to the console by means of the cable provided.

Step 4 - Turn on the instrument by turning the amplitude range selector switch from the OFF position.

The instrument requires five to ten minutes warm-up period for optimum operation.

Step 5 - Set amplitude range selector to TEST position; set frequency range selector to 5 position with filter out. The amplitude meter should read approximately - half scale, and the frequency meter should read 3600 cpm. These values have been preset to determine if the instrument is working properly. The filter can be switched IN and the tuning of the filter checked at 3600 cpm.

To operate Model 600 Vibration Analyzer, follow these steps:

Step 1 - Place the vibration pickup at the locations where the vibration is to be measured or analyzed.

Step 2 - The DISP-VEL selector is normally used in the DISP position.

Step 3 - Set the amplitude range selector to the least sensitive range (100); if the meter indicates less than 30 mils, change ranges until you obtain an up-scale reading.

Step 4 - Set the frequency range selector to the desired range.

Step 5 - Set filter control to OUT position or IN position as required.

The IRD Model 600 Vibration Analyzer serves three purposes, namely to measure vibration, to pinpoint the cause, and to correct imbalance inplace. When a component requires to be balanced in a balancing machine (IRD Model 107, 110 or 120), the analyzer serves as the electronic brain of the machine.

MEASURE VIBRATION - Any machinery having rotating components has a certain amount of vibration. When it becomes excessive, this vibration will cause undue wear to the machinery. To remedy this situation, the vibration must be periodically measured to assure that it is within tolerances.

This is effected by measuring the overall vibration, and the vibration of each component in the machinery. The readings obtained can be recorded on charts such as figure 3. This chart includes the reading positions, the space to record displacement, frequency, and when available, the manufacturer's vibration tolerances. Each time readings are taken, they are recorded and compared with previous readings.

PINPOINT THE CAUSE - Once the instrument has determined that excessive vibration exists, the next step is to pinpoint the cause, or to troubleshoot the machinery. The following are the steps to be taken to pinpoint the cause of vibration. These are not necessarily in their order of importance because each individual problem requires its own order of steps.

1 - Determine the nature of the difficulty on the equipment involved; find out how long the trouble has been occurring, whether any changes were made in the equipment which may have precipitated the trouble, and whether or not any steps have been taken in an attemp to correct the trouble.

2 - Become familiar with the equipment by making a thorough examination of its component parts; determine the approximate speeds involved in the rotating components associated with the equipment. Place reference chalks marks on rotors, belts etc.

3 - Measure the background vibration at the critical points on the equipment with the equipment completely shut down. This is the lowest level of vibration which can be attained on the equipment by taking corrective measures within the equipment itself; in the case of precision equipment such as precision machine tools the principle source of trouble is quite often transmitted vibrations from exterior sources and very little difference will be detected in the level of vibration with the machine running and the machine shut off completely. In any event, if the Vibration Analyzer detects the major source of the transmitted vibration, note this for future correction of the difficulty.

4 - Place the equipment into operation and again measure the vibration at the critical points. Determine the predominant cause of the vibration by relating the frequency of the vibration (filter out) to the various components and characteristics of the system under study; use the stroboscopic lamp to determine whether the vibration is in synchronism with any rotating or oscillating components with the system. In cases where many components in the machine are completely sealed and cannot be observed with the stroboscopic lamp, it is helpful to have

VIBRATION HISTORY

NAME_____
LOCATION_____
MACHINE_____
See Sketch On Attached Sheet

DATE _____
OPERATOR_____
INSTRUMENT MODEL_____

TEST CONDITIONS												
PICKUP POSITION	FILTER OUT		FILTER IN									
		CPM		CPM		CPM		CPM		CPM		CPM
H												
V												
A												
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H–HORIZONTAL V–VERTICAL A–AXIAL

I R D #475A

Figure 3 - Vibration Chart.

available a blueprint of the equipment in order that the frequency of the vibration can be related to the speed of some interior component. For rotating components which are visible, the stroboscopic lamp can be used in the OSC position to determine the rotating speed and slow down the rotating motion for visual observation of the component while they are running.

5 - When the vibration is measured at the critical points on a machine, a condition will sometimes be observed in which a "beat" or unsteady frequency reading is obtained due to the presence of more than one predominant source of vibration. The amplitude reading is also unusually somewhat unsteady. With these indications, use the variable filter to determine the various frequencies of vibration present, and the causes of these frequencies. When tuning the filter, the following procedures are recommended:

a) Turn the filter switch to the BROAD position.

b) Tune the filter carefully from lower to higher frequencies.

c) Always select the highest possible range on the amplitude range selector (1/3 full scale or more) for maximum accuracy and possible strob firing.

d) As the filter is being tuned, the presence of a measurable frequency component will be made known by observing that the frequency meter steadies to a fixed reading. When this is observed, tune to a peak amplitude indication.

e) In some cases better results will be obtained by using the SHARP filter position. The sharp filter should be carefully tuned, since, due to its higher Q, better rejection of vibrations of other frequencies than the one to which the instrument is being tuned, will be possible.

6 - Correct the major cause of vibration and again measure the vibration at the critical points. Determine the remaining sources of trouble, if any, and correct these as required. The level of vibration to which the machine is corrected is dependent upon many factors, which may at times be (1) whatever level is necessary to obtain satisfactory operation from the machine, (2) a vibration level specified by commercial tolerances or established tolerances, (3) the background level beyond which the vibration level cannot be reduced without correcting sources of trouble outside the machine, (4) the lowest level which can be obtained without major redesign of the equipment, or (5) the level which has been proved to be satisfactory by previous experience.

NOTE: Do not try to compute the frequency of vibration by the number of images obtained when observing a reference mark on the rotating part. Use the frequency meter.

7 - In cases where there are many various components in a given assembly which can be operated separately, it is sometimes helpful to operate each component

one at a time in order to determine which component is the major contributor to the overall amplitude of the vibration; the analysis can then be simplified by operating this section of the machine separately and correcting the source of difficulty.

When using the stroboscopic lamp, it is important to remember that the flash rate of the lamp is not normally controlled by the operator, but by the vibration signal. However, when on OSC position, the lamp flashes are adjusted with the tuning knob until the part being studied appears stopped. The lamp then becomes a tachometer.

When using the unit as a stroboscopic tachometer, with the switch in the OSC position, adjust the flash rate of the stroboscopic lamp to its maximum rate (5000 flashes per minute) by means of the tuning knob. Slowly reduce the flash rate until the rotating part under observation appears to be stopped or frozen as a single image. Record this flash rate as R_1. Continue to reduce the flash rate until the part again appears stopped, being very careful not to miss any flash rate at which this occurs. Record this flash rate as R_2. The rotating speed may then be determined as follows:

$$RPM = \frac{R_1 \ R_2}{R_1 - R_2}$$

Example:

By following this procedure, it is determined that the rotating part is visually "frozen" at flash rates of 4000 flashes per minute and 3000 flashes per minute.

$$RPM = \frac{\text{4000 times 3000}}{\text{4000 minus 3000}} = \frac{12000000}{1000}$$

RPM = 12000 Revolutions per minute

In this example, the rotating part would also be "frozen" at flash rates of 2400, 2000, 1714, 1500, etc. flashes per minute (every submultiple of 12000 flashes per minute) and any adjacent pair of readings can be used to determine the speed. For instance, if the 2400 flashes/minute and the 2000 flashes/minute readings were used, the calculation would be:

$$RPM = \frac{\text{2400 times 2000}}{\text{2400 minus 2000}} = \frac{4800000}{400}$$

RPM = 12000 Revolutions per minute

Using the tuning control and the two lower positions of the frequency range selector, the flash rate can be varied from 450 to 5000 flashes per minute. The internal oscillator is not operative on the higher positions of the frequency range selector.

To measure the velocity amplitude of the vibration, set the DISP-VEL indicator to the VEL position. Velocity measurements are normally used to analyze very high frequency vibrations which have a very low and almost undistinguishable displacement, but a considerably evident velocity. Velocity measurements are normally more effective than displacement measurements for balancing at very high speeds.

There is a very useful feature incorporated in the Model 600 to facilitate tuning the filter to the speed of the rotating component. Identical circuitry is used for both the filter and the oscillator; if the oscillator is tuned such that the flashing rate of the strob lamp is in synchronization with the rotation, this procedure also tunes the filter to the proper setting.

Although the maximum flash rate of the strob light is only 5,000 times per minute this does not limit the use of the strob. The instrument automatically reduces the flash rate by an even submultiple of the actual vibration frequency. For instance, if the machine speed and vibration frequency is 9,000 CPM, the instrument would automatically reduce the flash rate to 4,500 per minute. This action in no way effects the use of the strob light for balancing or freezing bad parts, slow motion studies or tachometer observations.

Relative phase is measured when the strob lamp is being triggered by the signal vibration pickup by virtue of the fact that the strob light is not only triggered once for every cycle of vibration but also is triggered at one particular instant throughout the cycle. In other words, if a motor bearing is vibrating back and forth to the left and right in a lateral direction, and a keyway or reference mark on the motor shaft is being observed with the stroboscopic lamp, the angular position of the keyway or reference mark as observed when the pickup is applied to the left side of the bearing would be directly opposite or 180 degrees out of phase with respect to the angular position as observed when the pickup is applied to the right side of the bearing.

Typical vibration characteristics resulting from specific troubles are as follows:

1 - BEARINGS - A rough anti-friction bearing results in a relatively high frequency of vibration which is several times the frequency of the rotating member which is mounted in the bearing but not necessarily a direct multiple of that speed. The frequency reading is usually unsteady, and the amplitude reading may be somewhat unsteady also. The vibration due to a rough bearing of this type may be distinguished from high frequency electrical vibrations by virtue of the fact that the bearing vibrations will continue even after the electrical driving power is removed and the rotating member mounted in the bearing is coasting to a stop.

2. BEARINGS - An anti-friction bearing can cause vibration due to the fact that the inner and outer races possess a certain amount of angular misalignment. This vibration will occur primarily in the end-wise or axial direction with respect to the shaft which is mounted in the bearing and occurs at a frequency equivalent to the rotor speed.

3. NON-CONCENTRICITY - Lack of concentricity in an anti-friction bearing causes vibration which usually becomes apparent only at a low level of vibration when a precision degree of balance is being accomplished on the equipment which is running in the bearing. This may result in a vibrational frequency equivalent to the rotational speed of the part running in the bearing; the characteristics are such that it acts like an imbalance which shows up only in one radial direction (horizontal, vertical, or some other specific angle). The equipment can be balanced to a very low level with respect to

the vibration in one direction but will not possess a low level of vibration in another.

4. EXCESSIVE CLEARANCE - Conditions of excessive clearance within a sleeve bearing can be detected by the difference in the amplitude reading which is obtained on the bearing housing in comparison with the amplitude which is obtained by directly measuring the vibration on the shaft which is running in the bearing.

5. BELTS - Belt vibrations can be set up in which the frequency of vibration is equivalent to the rotational (not peripheral) speed of the belt or a multiple of the rotational speed. In such a case the stroboscopic lamp will "freeze" or "stop" a chalk mark placed on the belt, and "freeze" or "stop" the mark in one certain area or position or several positions in the event that the belt vibration is a multiple of the belt rotational speed. Belt vibrations are sometimes somewhat unsteady with respect to both amplitude and frequency, and are usually low in frequency due to the fact that the rotational speed of belt drives is usually low. In cases where a multiple belt drive is being used and several belts may be causing the overall vibration, the observation of one of the belts with the stroboscopic lamp may show a tendency to stop a mark on the belt in one given position (the mark would appear in one area of the belt more often than in other areas) rather than a fixed "stopping" of the belt.

6 - AERODYNAMICS - Aerodynamic vibrations may arise from several sources, such as (1) unequal pitch on the blades of a propeller-like system in which the axial force against one blade is not equal to the axial force against the remaining blades, resulting in a vibration which occurs at a frequency equivalent to the rotating speed and is primarily (but not totally) acting in the endwise or axial direction, (2) blade flutter may be encountered at the resonant frequency of the blades if there is some source of energy at that frequency to excite the blade or blades, and (3) duct work, shrouds, piping, etc., can be excited to resonance by the flow of air, gas, or liquid through the system.

7 - HYDRAULICS - Hydraulic vibrations may result from such causes as cavitation in pumps, vibrations excited by fluid flow, etc. Hydraulic systems are sometimes a source of troublesome vibrations on precision machine tools; this may be due to imbalance in the pumps, and is normally corrected by isolating the pump from the remainder of the machine.

8 - MECHANICAL - In practical vibration problems, a condition frequently arises in which the frequency of vibration is twice that of the rotating speed on a particular component which is being analyzed; this is usually referred to as a "double frequency" or a "double picture" (When the stroboscopic lamp is used to observe the rotating component, the vibration picked up by the pickup triggers the stroboscopic lamp twice for each revolution of the rotating part, and a reference mark appears to be stopped in two positions rather than one). This is usually an indication of some mechanical source

of vibration such as looseness, rubbing, wear, excessive play between mating parts, etc. One exception to this is the case of reciprocating components being driven from a crankshaft; in this case a "double frequency" arises naturally from the forces within the system.

9 - ELECTRICAL - Some types of vibration may be electrical in nature, such as case vibrations in transformers which are induced by the alternating electromagnetic fields. Another source of electrical vibration which is frequently encountered is torque pulses in single phase electrical motors; these result from the fact that the movement of the rotor throughout one revolution is not constant but consists of a series of jerks as the rotor passes each pole within the motor. This vibration occurs at synchronous frequency or some multiple of synchronous frequency.

10 - GEARS - Gears may be the cause of vibrations, the frequency of which is dependent upon the nature of the trouble and the character of the assembly in which the gear is mounted. For example, if tooth interference is taking place between two mating gears, the frequency of vibration on one gear will be equivalent to the product of the number of teeth on the gear and the gear speed in revolutions per minute. If a gear has a high tooth, the frequency of vibration will be equivalent to the product of the gear speed in revolutions per minute and the number of other gears with which the gear meshes.

11 - OIL WHIRL - In equipment which is designed to operate at a speed well above the shaft is running in lubricated sleeve bearings, a condition may arise in which "oil whip" may develop within the bearing and cause the shaft to "whirl" at a speed which is lower than the rotational speed. This "whirl" speed is often in the order of one-half the rotational speed, and the resultant vibration is approximately equivalent in frequency to one-half the rotation speed. This condition is usually corrected by altering the design of the bearing or changing the conditions of lubrication.

12 - RESONANCE - In some cases the reason that trouble is being encountered can be traced to the fact that system resonance is occuring at or near the operating speed of some component within the system, and vibrations which otherwise would be small are magnified. This can be detected by shutting off the power source and noting the manner in which the amplitude of vibration varies as the equipment coasts to a stop. By observing the amplitude and frequency readings while the equipment is slowing down, the frequencies can be noted at which the amplitude readings rise to a peak; these are the resonant or critical speeds. If the amplitude falls off very sharply as the equipment slows from operating speed, it is then apparent that the equipment is running near resonance. When this is the case, the amplitude of vibration can be reduced to a low level by (1) balancing to a high degree of precision the component which is exciting the resonance, or (2) modifying the system to change the resonance. Unless it is practical to obtain a precision balance and maintain it throughout the life of the equipment, some effort to change the resonance is usually warranted.

13 - MISALIGNMENT - Mechanical troubles such as misalignment or bent shafting can cause vibration difficulties. Since these conditions result in the rotating mass being displaced from its correct operating axis, the system may actually be out of balance although weight distribution within the part if not the primary source of trouble; the indications which result may be similar to those due to ordinary imbalance, but normal balancing procedures may not completely solve the trouble if the mechanical troubles are of a sufficiently major degree. Misalignment or bent shafts may result in a vibration frequency equivalent to twice the rotating frequency, resulting in a characteristic "double frequency" of vibration; the exact manner in which a misalignment will manifest itself depends upon the degree of misalignment, type of bearings, type of couplings, and equipment being used. It is recommended that the alignment always be checked if it is suspected as a source of trouble. This type of mechanical trouble often causes a high level of vibration in the endwise or axial direction on a bearing.

In cases where the shaft vibration should be measured, the pickup can be placed at the bearing points. However, if this is impractical, measurements can be taken by using a sharp-edged wooden probe such as the IRD PH-1 shaft stick. The probing end of this wooden extension should be razoredged and V-shaped to ride against the shaft. Hard wood such as maple should be used. Lubricating oil should be applied to permit riding ease on the shaft.

The General Machinery Vibration Severity Chart applies to machinery such as motors, fans and blowers, pumps and other machinery which does not directly influence the quality of the finished product. Note the specific tolerances are not indicated but rather a range of severity. Wide variations from these values may be expected from individual machines.

The values on the second chart are for shipboard equipment as noted in MIL-STD-167 (SHIPS) 12/20/54.

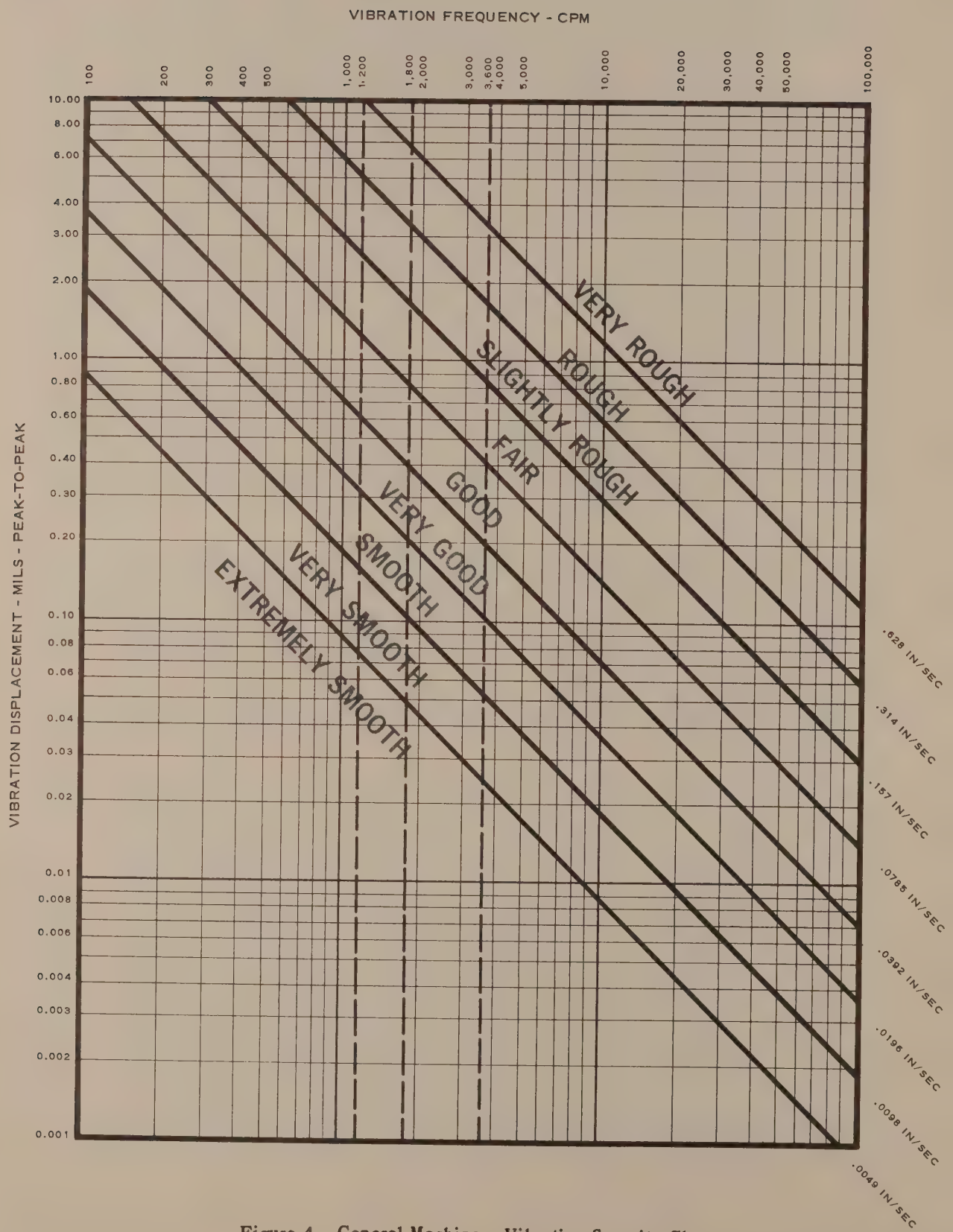
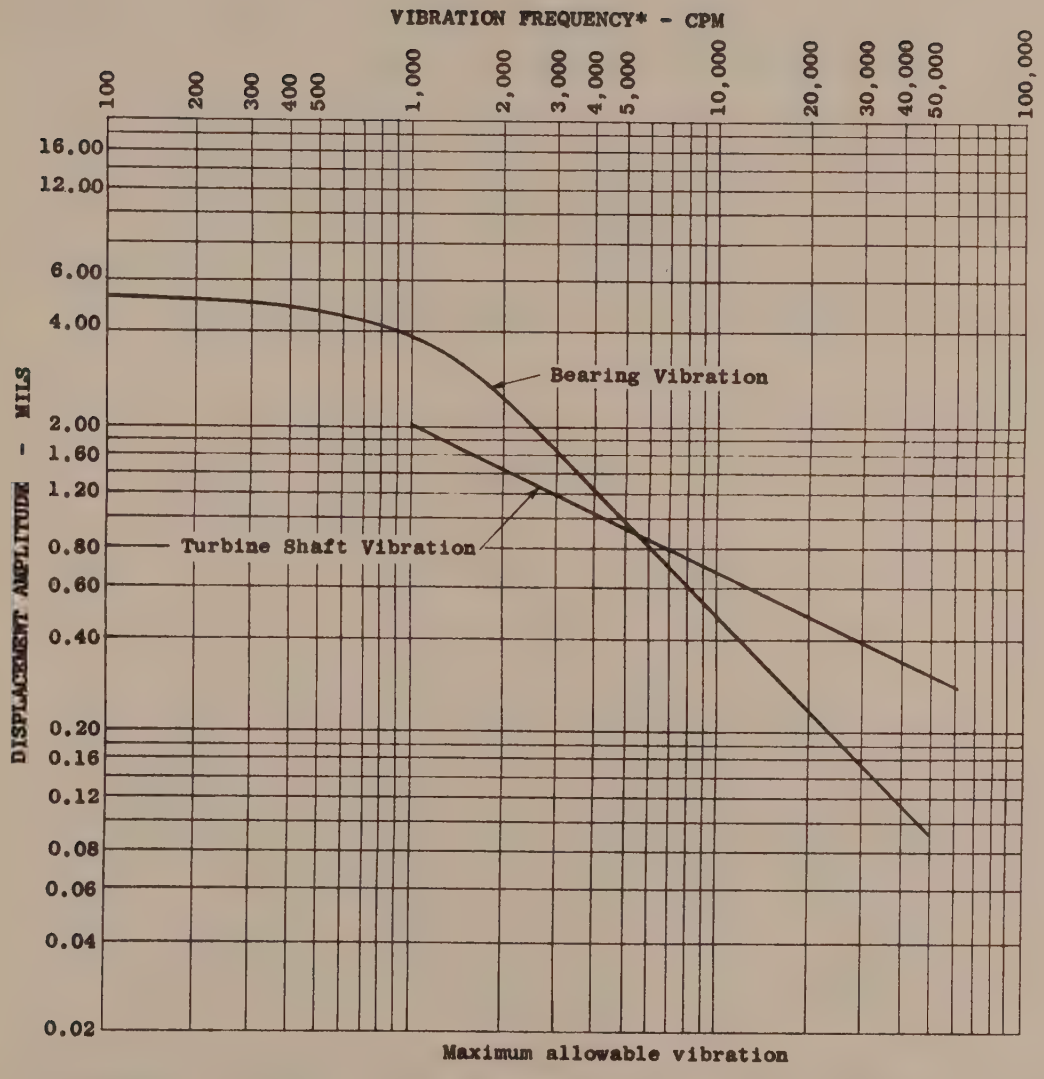


Figure 4 General Machinery Vibration Severity Chart



* Frequency corresponds to RPM when dynamic imbalance is the cause of vibration

Figure 5– Shipboard Equipment Vibration Chart MIL–STD–167 (SHIPS) 12/20/54

IN-PLACE BALANCING

BASIC REQUIREMENTS

A. Vibration must be due to imbalance.

1. Stroboscopic lamp "freezes" or "stops" rotating part which being triggered by the vibration pickup. If necessary, the filter can be used to screen out background vibrations.

   a. In using the filter, if the speed control is not within 1% from run to run, the filter should be reset for each run by switching to OSC and adjusting the tuner, until the strob light is in synchronism with the rotation. This is especially true when using the sharp filter.

   b. When balancing at mechanical resonance, care should be taken that the phase shift variation with speed does not cause false readings.

GENERAL PROCEDURE

A. Place reference mark on rotating system for phase determination.

1. Keyway, scratch, etc. can be used for reference mark if first set of data is taken before equipment is shut down.

2. Place mark radially from rotating axis.

3. The end of a shaft is often the best place for the reference mark, since the position is very readily observed.

4. If there is a possibility of looseness or slippage between mating portions of a rotating assembly, mark each portion in order that it may be observed whether or not the physical relationship of the various parts of the assembly is constant throughout the job.

5. Mark can be placed at either end of a rotating assembly, but all data must be taken from one end throughout the balancing procedure.

6. If only a side view is available, use a sequence of numerals around the rotating part.

a. Numbered tape is sometimes helpful.

B. Locate points where vibration measurement will be taken.

1. Use points where sensitivity is high (high amplitude of vibration) and frequency reading steady at speed or rotating part.

a. Compromise to measure in the same direction when taking data at both ends.

2. Take measurements as close to bearings as possible.

a. If it is known that the shaft is true and has a smooth surface, it is sometimes advantageous to measure vibrations directly on the shaft.

3. On some equipment, balancing can be accomplished by measuring on a housing, foundation, support, pipe or other extension, etc.

4. Take measurements from same point or points and in same directions throughout balancing runs.

a. One point usually sufficient for each balancing plane.

b. Both vertical and horizontal measurements for each balancing planes sometimes helpful if conveniently taken.

C. Observe and record background level of vibration with apparatus shut down and not running.

1. Background level is lowest level to which equipment can be balanced.

2. If the Vibration Analyzer diagnoses the source of background vibration, correct or note for future correction.

D. Observe and record original running conditions.

1. Record amplitude in inches or mils.

2. Record relative phase angle in degrees or apparent clock position in hours.

3. Repeat original runs if (1) instability is suspected, (2) equipment appears to be running near mechanical resonance, or (3) poor speed control is suspected.

a. Check for consistency in readings.

b. Use oscillator to ensure that runs are being taken at exactly the same speed if poor speed control is being encountered.

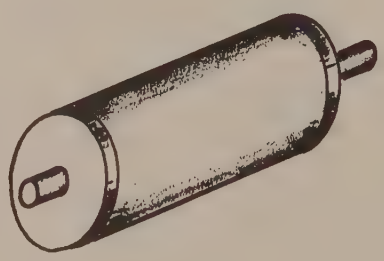
What is imbalance -

One of the most common causes of vibration in machinery is imbalance of the rotating components. This imbalance is mostly due to a heavy spot or weight for which there is no compensation on the opposite side of the rotating part. This heavy spot or weight may be caused by faulty design or faulty mechanical assembly.

The common term used to specify the degree of imbalance is ounce-inches; similar terms such as pound-inches, gram-inches, and micro-ounce-inches are sometimes used. These terms indicate the amount of weight and the distance from the center where the weight should be applied. For example, if a two-ounce weight is added to a flywheel at 5 inches from the center, the imbalance is expressed as 10 ounce-inches; if the weight is one ounce at 10 inches or 10 ounces at one inch, the result is also 10 ounce-inches. The same terms apply if a part is not mounted on its true center. For example, if a 20 pound (320 ounces) pulley is mounted two thousandths of one inch (.002") off center, the resulting imbalance is 320 x .002 = 0.64 ounce inches.

Balancing problems in production and in the field are normally classified as single-plane, two-plane, and multi-plane problems.

SINGLE PLANE



TWO PLANE

Single-plane problems are those in which the diameter of a rotating part is large as compared to its length, such as most grinding wheels, single groove pulleys, three and four bladed fans, pump impellers, flywheels, etc. Single-plane imbalance is often called static imbalance because, if it is severe enough, it can be detected by resting the part on rails and letting the heavy spot fall to the bottom; for example, when a bicycle wheel is rotated freely, the air valve (the heavy spot in this case) will fall to the bottom.

A part which is relatively long as compared to its diameter, such as an armature, a spindle, a shaft, etc., cannot be balanced in a single plane. This type of imbalance is called dynamic imbalance and is referred to as a two-plane problem. If the part is extremely long, or if the rotating speed of the part causes the weight of the heavy spot to "bend" the part, it may be necessary to balance in several planes.

Balancing Methods -

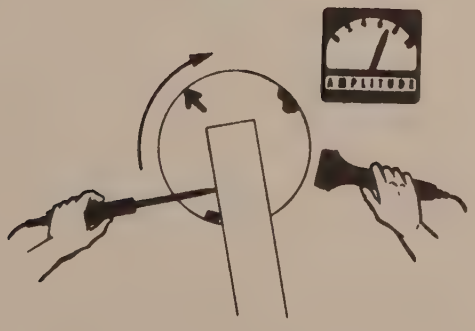
There are two basic methods of determining the location and the weight to be added or taken-off; they are the five-step method and the vector method. In production balancing, a simpler and quicker method will apply.

The five-step method is simple and convenient when the number of trial runs is not important and when the part is easily started and stopped. To illustrate this method, consider the case of a pulley as being the cause of predominant vibration.

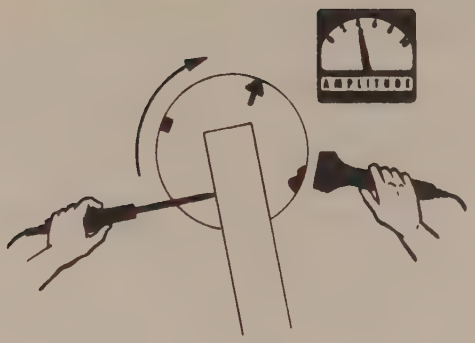
Step 1 - Make a reference mark (chalk mark, keyway, paint spot, etc.) on the pulley in order to see where the mark is each time the stroboscopic lamp is triggered.

Step 2 - Place the pickup on the bearing or housing nearest the pulley and observe amplitude meter and position of mark.

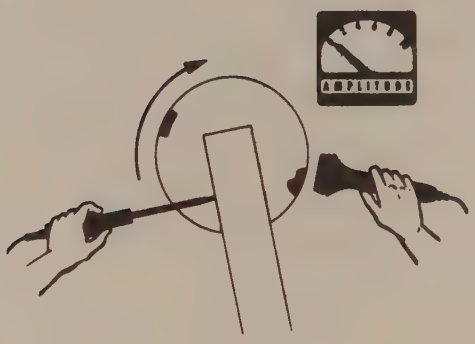
Step 3 - Add a weight to the pulley and observe the angular shift of the reference mark.



Step 4 - If the mark has moved, shift the weight in the opposite direction of the move until the mark returns to its original position or directly opposite.



Step 5 - Add or subtract weight until an acceptable degree of balance is obtained.



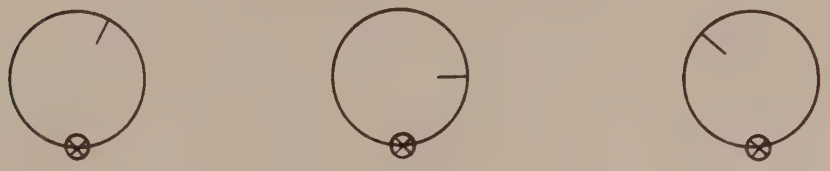
Rules of five-step method -

1. Always compare conditions with the first run.
2. Always move the weight in opposite direction of the shift of the mark from initial run.
3. Move the weight less than 90 degrees if vibration decreases.
4. Move the weight 180 degrees if the mark remains in the same original position and vibration increases.
5. When the mark returns to the original position, increase the weight until balance is obtained.
6. When the mark moves directly opposite its original position, reduce weight until balance is obtained.
7. Always hold the pickup at the same location and in the same direction with each run.

In cases in which it is necessary to balance a part often such as a grinding wheel, the following short cut method can be used. First the wheel is balanced using either the five-step or the vector method, noting the location of the heavy spot; then, pro-

viding the mass of the wheel is approximately the same, and the pickup is held in the same direction as in the first balancing, the heavy spot will be at the same location in relation to the reference mark each time the wheel is to be balanced. For example:

FIRST TIME SECOND TIME THIRD TIME



Note that the first time the wheel was balanced, the heavy spot (sometimes called the flash angle) was at 6:00 and the reference mark was at 1:00; subsequent balancings produced a different location of the reference mark but the heavy spot remained at 6:00. Consequently, to reduce the five-step method to one step, one is required to notice the original location of the heavy spot. Thereafter, this spot will always be in the same location in relation to the reference mark.

The vector method is most efficient when time and number of runs are important.

To illustrate the method, consider the case of a thin flywheel:

1. Make a reference mark as in the five-step method.

2. Place the pickup on the bearing or housing nearest the flywheel and record amplitude meter readings and position of the mark.

   Example: .060" with mark at 1:30.

3. Draw line "O" (original) on paper at the same angle as that of the mark, and with a length proportional to the amplitude.

4. Add a test weight the size you think is approximately correct at any place on the flywheel.

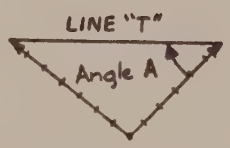
5. On this run, record the new amplitude readings and the new position of the mark.

   Example: First run - .060" at 1:30.

   Second run - .070" at 10:30.

6. Add line "R" (result of adding weight to original) to the diagram with length and angle corresponding to the new reading.

7. Draw a line from the end of Line "O" to the end of line "R". This is now line "T".



The angle "A" between line "O" and line "T" tells the direction and degree that the weight should be shifted. In the above example, the weight should be moved 55 degrees clockwise from its present position. The weight is always shifted in the direction opposite the shift of the mark.

The length of the line "T" represents the effect of the test weight. The length of line "O" represents the effect of the original imbalance. The test weight should be increased or decreased according to the ratio of line "O" to line "T". In the above example, if the test weight is 10 grams, line "O" is two inches long, and line "T" is three inches long, the correct weight to be used is 10 x 2/3 = 6-2/3 grams.

8. This will not always work out on the first run because the diagrams cannot be 100% exact, and the length of the lines cannot absolutely correspond to the exact amount of imbalance. Further runs can be made and more diagrams can be drawn. Suppose the above change was made and another run taken.

   The new vibration condition is:

   First run - .060" at 1:30.

Second run - .070" at 10:30.

Third run - .010" at 6:00.

Angle "A" indicates that the weight should be shifted slightly counterclockwise (about 10^{o}) and the length ratio of line "O" to line "T" shows that the weight should be reduced slightly.

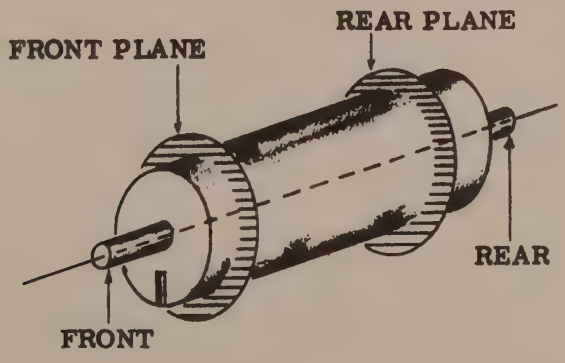
9. For finer balance, repeat this procedure, always comparing readings with the original conditions.

Two-plane balancing problems may be solved by using the same procedures as described in the previous paragraphs, and treating each end as a separate problem. However, the vector method should be used because it is the more accurate of the two in this case. When using this method, the reference mark and its shifts should always be observed at the same end of the part regardless which end is being balanced. Each step of the vector method should be followed. However, the amplitude readings must be taken at both ends of the part regardless which end is being balanced.

In some two-plane problems, after balancing one plane then the other, it may be necessary to rebalance the first plane again. This is due to cross-effect that may be introduced in the rotating part when a weight is added to one plane; this cross-effect may cause vibration at the other plane. Cross-effect is generally more severe when the correction planes are relatively close together.

In a typical two-plane problem, assume that the reference mark is the keyway and that the initial readings are:

	FRONT	REAR
Run #1	.018" at 6:00	.019" at 5:00

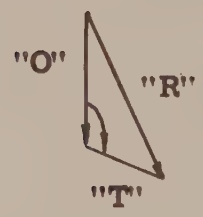


Where, as in the case above, the amplitude readings and the angle of the mark are comparable at both ends, the imbalance is roughly at the same angle and the amount similar at each end. In such a case, a single-plane correction at the center, or equal weights at each plane, (sometimes called a "static" correction) will probably remove most of the imbalance. To make such a correction, one must assume that the rotating member is fairly symmetrical and that the rigidity of the bearing mounts at each end is comparable. Assuming then that we add 10 ounce-inches in line with keyway at each plane and that the readings are:

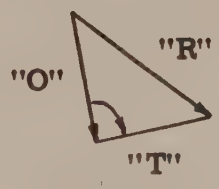
	FRONT	REAR
Run #1	.018" at 6:00	.019" at 5:00
Run #2	.021" at 5:00	.023" at 4:00

Draw a vector sketch for each plane to determine the proper moves.

FRONT



REAR



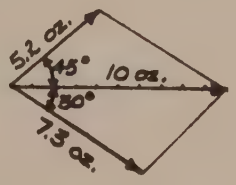
These sketches indicate that we should move the weights 100 degrees clockwise from the keyway and increase then to 15 ounce-inches at each plane. The readings now becomes:

	FRONT	REAR
Run #1	.018" at 6:00	.019" at 5:00
Run #2	.021" at 5:00	.023" at 4:00
Run #3	.005" at 6:00	.003" at 2:00

Since the reference mark now appears at different angles for each end, further attempts to statically balance the part would be useless. The next step is to consider each end as a separate balancing problem starting with the front because the amplitude is greater at that end. The corrections already made should not be disturbed; this now is a new problem. Start with run #3 as the original run.

In many two-plane balancing problems, the phase lag at each end of the system will be the same or very nearly the same. Therefore, after the angle at which the heavy spot fires the light has been determined at one end, this information may be used to locate the point on the other end at which the trial weight should be added.

There are occasions when the weight must be divided between two positions because there may be only certain places on the part on which correction can be made. In these cases, a vector sketch can be drawn to determine the amount and position of each weight. For example, suppose 10 ounce should be added at a certain point, but the only places available are at 30 degrees clockwise and 45 degrees counter-clockwise from the spot where the weight should be added. The sketch is drawn to scale as a parallelogram with the 10 ounce line as the diagonal; the length of the sides indicates the amount of weight to be added at each piece.



As seen in the above diagram, 7.3 ounces should be added at 30 degrees clockwise and 5.2 ounces should be added at 45 degrees counter-clockwise. Note here that the two weights amount to more than 10 ounces; that is normal because, when correction weights are divided, a greater weight is required than if it were placed in one location.

In balancing various types of components, temporary weights are normally used before permanent weights are attached. The only exception is in production balancing where the system has been previously calibrated by the flash-angle method to quickly determine the location and amount of balancing correction.

Typical means of applying temporary weights are:

1. Using balancing clay on the rotating part.

2. Adding bolts, nuts, or washers to through holes, tapped holes, or threaded studs.

3. Clipping weights and U-clamps (mounted in such a manner that centrifugal force helps in holding the weights.

4. Adding layers of short lengths of tape (for fine correction on very light components).

5. Adding weights in accordance with balancing provisions by the manufacturer of the equipment being balanced.

6. Fastening weights to metal baling bands strapped around the part (for cylindrical surfaces on which there is no ready means of adding weight).

After balancing has been obtained with temporary weights, these must be replaced by permanent type ones. It is very important to remember that the permanent cor-

rection must be equal in ounce-inches to the temporary weight. This is also very important when the final correction cannot be made at the same radius as the temporary weight was located. Typical means of making permanent corrections are:

1. Welding metal weights (the weight of the welding material must be taken into consideration).

2. Soldering.

3. Permanently attaching weights in accordance with provisions made by the manufacturer.

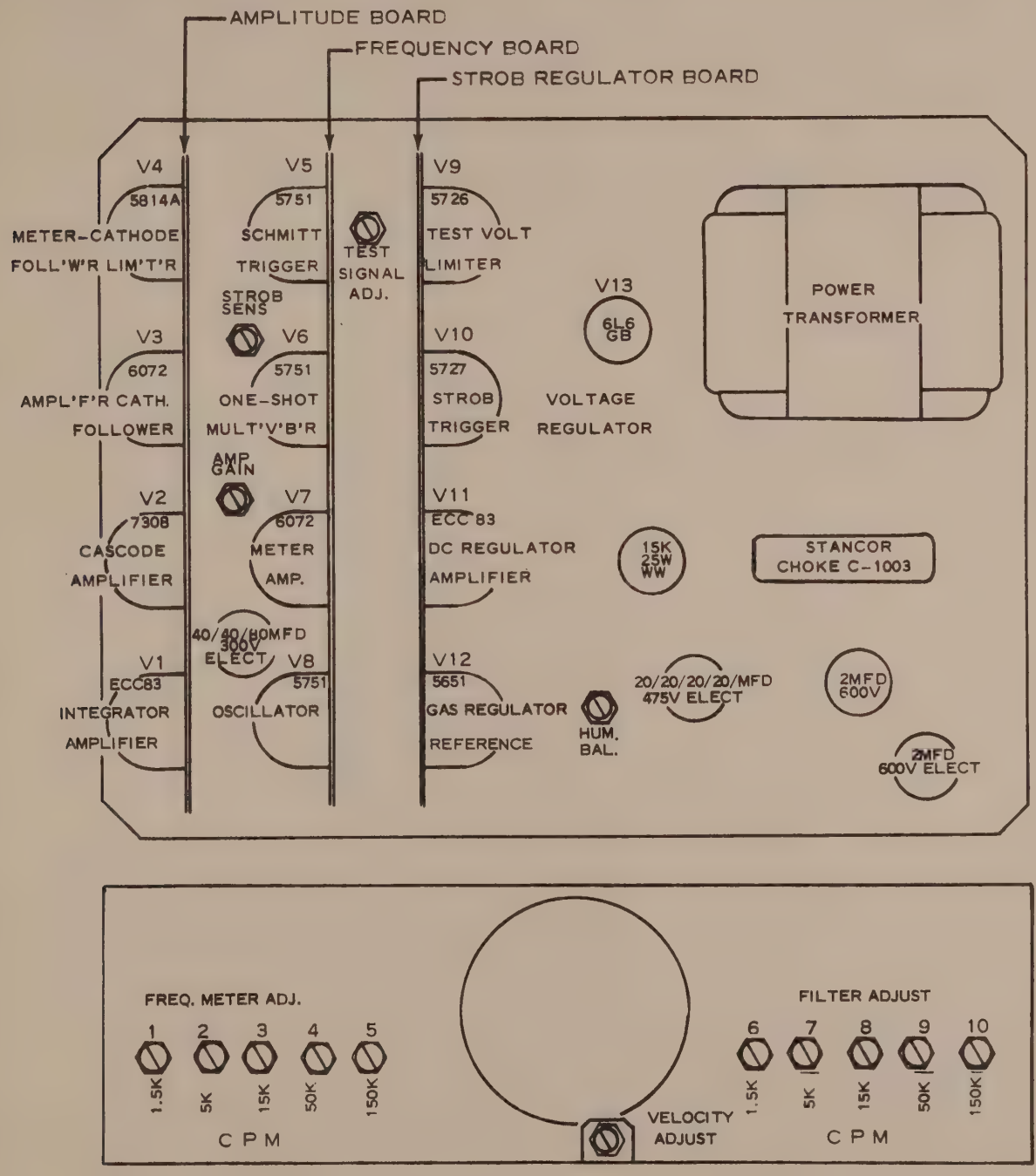
4. Adding bolts, nuts, or washers to through holes, tapped holes, or threaded studs.

5. Drilling, grinding, or filing.

6. Fastening clips or U-clamps permanently.

When balance correction is being made by drilling, grinding, or filing, it must be remembered that weight must be removed directly opposite from where the trial weight was added. In such cases where weight is removed, a shift of the reference mark may occur. In this case, the remainder of the weight should be removed in the opposite direction of the shift of the mark.

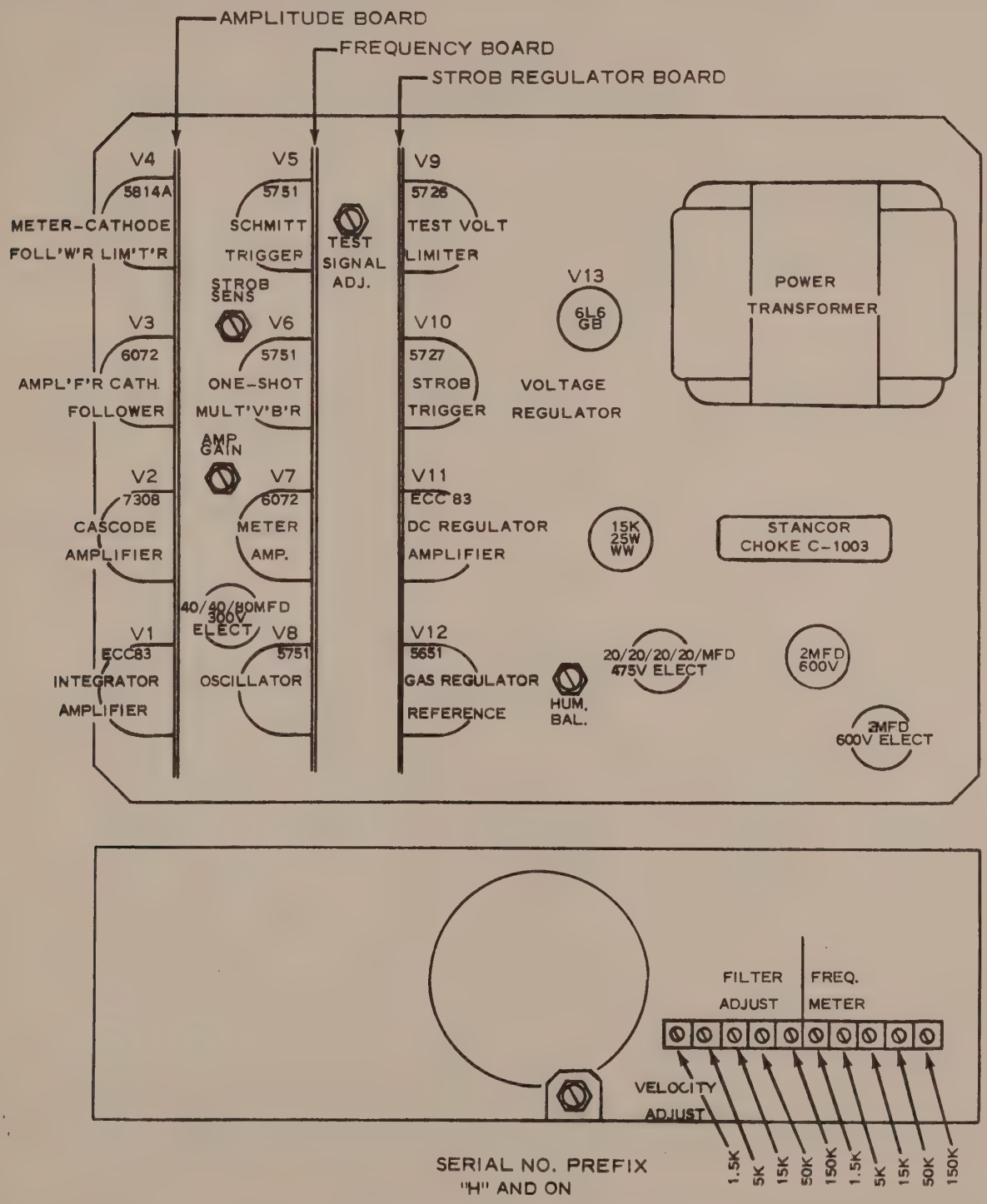
Model 600 can easily serve as the electronic brain to any IRD Dynamic Balancing Machines, thus eliminating costly duplication of instruments. No special tooling is required; simply connect the Analyzer to the machine.



SERIAL NO. WITH NO PREFIX
AND SERIAL NO PREFIX A-G

TUBE LAYOUT-MODEL 600

NOTE:
V2-5814 IN NON
BROAD SHARP
INSTRUMENT



TUBE LAYOUT-MODEL 600

APPENDIX A

MODEL 600 VIBRATION ANALYZER

Preliminary Performance Checks and Calibration Instructions

General

Circuit Symbol	Type
V1	ECC83
V2	7308
V4	5814
V3, V7	6072

Whenever one of the above listed tubes is replaced, the instrument should be recalibrated as directed in the CALIBRATION PROCEDURE (Section B Preliminary Gain Adjustment) or in the case of V7, Section D Calibration of the Frequency Meter.

Preliminary Performance Checks

Amplitude, Frequency and Filter Circuits:

Set the Mils-Ins/Sec. Range Switch to the Test position and the Frequency Range Switch to 5. The Frequency Meter should now indicate the line frequency (usually 3600) and the Amplitude Meter should indicate approximately 1/2 scale with the Filter at the Out position. With the Filter at the In position, rotate the tuning control until a peak reading is attained on the Amplitude Meter. This reading should be the same as the Filter Out reading. If the above readings are observed, the Amplitude, Frequency and Filter Circuits are functioning. If the readings are incorrect and maintenance is not required, proceed with the calibration as directed in the Calibration Section.

Vibration Pickup

The pickup should now be connected to the Analyzer and held in the hand. Wit the Mils-Ins/Sec. Switch at the .1 position, the Frequency Range Switch at 5 and the Filter at the Out position, erratic but appreciable meter readings should be observed. This is caused by the slight motion of the hand. If a reading is not attained, check

the pickup cable by resistance measurements and/or the pickup with a sensitive A.C. VTVM.

Oscillator

Set the Filter-Oscillator-Selector at the Oscillator position and the Frequency Range Switch at the 1.5 or 5 position. Vary the Tuning Control and note the Frequency Meter indication. If a proper frequency reading is not observed (as indicated by the Filter-Osc.-Dial) check the oscillator circuit located in the vertical mounted frequency board.

Strob Lamp

If a steady frequency reading is observed in the previous tests, connect the Strob Lamp to the Analyzer. If the strob bulb does not light, check the bulb by replacement. Caution: The power should be turned off while replacement is being made. If the strob bulb still does not light, check the cable by resistance measurements or plug the strob light directly into the strob connector on the rear panel.

Calibration

A. Amplitude and Frequency Meter zero adjustment

1. Set the Mils-Ins/Sec Switch at the OFF position.

2. Adjust the small screw located at the front center of each meter until the indication is exactly zero.

B. Preliminary Gain Adjustment

1. Connect the signal generator to the pickup connector, located on the rear panel.

2. Set the Mils-Ins/Sec Switch at the 1 mil position.

3. Set the Disp-Vel switch at Disp.

4. Adjust the signal generator output for 240 MV ±2% at exactly 100 cycles per second. If the output

voltage of the vibration pickup that will be used with the instrument is known, for a shake of .314 in/sec at approximately 100 cps, this voltage should be used in lieu of the 240 MV mentioned above.

The exact sensitivity of the Model 544 Pickups with serial number prefix "C" and on is indicated by the last three digits of the serial number.

5. Adjust the Overall Gain Control for full scale deflection on the Amplitude Meter. This control is located on the large printed circuit board, between the vertical mounted boards and toward the front.

C. Velocity Adjustment

The maximum velocity is dependent on both amplitude and frequency. To set the velocity adjustment control correctly, proceed as follows:

1. Set the signal generator for an output signal corresponding to B-4.

2. Set the Disp-Vel switch at the Vel position.

3. The Mils-Ins/Sec switch remains on the 1 mil range.

4. Set the Velocity Adjustment control until a full scale meter reading is observed on the top scale. This control is mounted on the inside front panel directly between the two meters. After completing this step the Amplitude Meters will indicate full scale on the top scale. The correct velocity reading in In/Sec should be read from the lower scale. Thus: Velocity= 0.314 In/Sec Peak for 1 mil Peak-to-Peak Displacement at 100 cps.

D. Calibration of the Frequency Meter

The Frequency Meter circuit is provided with an adjustment for each frequency range. For maximum accuracy, each range must be individually calibrated. Approximately 9/10 scale reading has been arbitrarily chosen as the calibration point for each range. To calibrate the Frequency Meter proceed as follows:

Location Of Frequency Calibrate Controls:

Instruments with no letter prefix on S/N, and S/N with S/N prefix A through G inclusive, the frequency calibrate controls are located behind the Amplitude meter. Number 1 is on the left side and is for the X1.5 range. No. 2, 3, 4 and 5 are for the X5, X15, X50 and X150 ranges respectively. On instruments with S/N prefix H and above, these controls are located on the far right side behind the frequency meter.

The sixth control from the left is for the X1.5 range. No. 7, 8, 9, and 10 are for the X5, X15, X50 and X150 ranges respectively.

1. Set the input signal frequency at 20 cycles per second. Adjust the signal amplitude to attain an on-scale amplitude meter reading.

2. Set the Frequency Range switch at 1.5.

3. The Frequency Meter should now read 1200 cpm. If not, adjust the Frequency Meter Adjustment control until this reading is attained.

4. The 5K cycle per minute range calibration is described under Section G-Test Signal Adjustment.

5. Set the input signal frequency at 200 cycles per second.

6. Set the Frequency Range switch at 15.

7. The Frequency Meter should now read 12,000 cpm. If not, adjust the Frequency Meter Adjustment control until this reading is attained.

8. Set the input signal frequency at 700 cycles per second.

9. Set the Frequency Range switch at 50.

10. The Frequency Meter should now read 42,000 cpm. If not, adjust the Frequency Meter Adjustment control until this reading is attained.

11. Set the input signal frequency at 2000 cycles per second.

12. Set the Frequency Range switch at 150.

13. The Frequency Meter should now read 120,000 cpm. If not, adjust the Frequency Meter Adjustment control until this reading is attained.

E. Calibration of the Tunable Filter

The Filter Adjustment controls should be checked for proper adjustment when the tubes in the filter are replaced or whenever the In and Out, filtered Amplitude Meter readings differ appreciably with a sinusoidal input to the instrument. If the Broad Sharp Filter is incorporated in the analyzer, all filters in amplitude calibration adjustments should be made in the sharp position.

The correlation between the Broad and Sharp filtered amplitude meter readings should be within ±3%.

Location Of Filter Calibrate Controls:

Instruments with no letter prefix on S/N, and S/N with prefix A through G inclusive, the Filter calibrate controls are located behind the frequency meter. Number 6 is on the left side and is for the X1.5 range. Numbers 7, 8, 9 and 10 are for the X-5, X-15, X-50 and X-150 ranges respectively.

On instruments with the S/N prefix H and above, these controls are located on the left side behind the frequency meter. The first control is for the X1.5 range. Numbers 2, 3, 4 and 5 are for the X-5, X-15, X-50, and X-150 ranges respectively.

To adjust the filter circuits for proper operation proceed as follows:

1. Set the Mils-In/Sec switch at the 1 mil position.

2. Set the Filter-Osc. Selector at Out.

3. Set the Frequency Range switch at 1.5.

4. Set the Disp-Vel switch at Disp.

5. Apply a 20 cycle per second signal and adjust the signal generator output attenuator for an amplitude meter indication of exactly 9/10 full scale.

6. Switch the Filter-Osc. Selector to IN.

7. Turn the Filter-Osc. Tuning dial to 1200 cpm while watching the Amplitude Meter. At approximately 1200 cpm a peak meter indication of 9/10 full scale will be observed, as was the case at the OUT position (Step 5.).

8. If the IN and OUT meter indications are not exactly the same; adjust the Filter Adjustment Control until correlation is attained. Always rock the Filter-Osc. Tuning control back and forth to assure an accurate adjustment.

9. Set the Filter-Osc. Selector switch at OUT.

10. Set the Frequency Range switch at 5.

11. Apply a 70 cycle per second signal and adjust the signal generator output attenuator for an amplitude meter indication of exactly 9/10 of full scale.

12. Switch the Filter-Osc. Selector to IN.

13. Turn the Filter-Osc. dial to 4200 cpm while watching the Amplitude Meter. At approximately 4200 cpm a peak meter indication of 9/10 full scale will be observed, as was the case at the OUT position (Step 11).

14. If the IN and OUT meter indications are not exactly the same; adjust the Filter Adjustment Control until correlation is attained.

15. Set the Filter-Osc. Selector switch at OUT.

16. Set the Frequency Range switch at 15.

17. Apply a 200 cycle per second signal and adjust the signal generator output attenuator for an amplitude meter indication of exactly 9/10 of full scale.

18. Switch the Filter-Osc. Selector to IN.

19. Turn the Filter-Osc. Tuning dial to 12,000 cpm while watching the Amplitude Meter. At approximately 12,000 cpm a peak meter indication of 9/10 full scale will be observed, as was the case at the OUT position (Step 17).

20. If the IN and OUT meter indications are not exactly the same; adjust the Filter Adjustment Control until correlation is attained.

21. Set the Filter-Osc. Selector switch at OUT.

22. Set the Frequency Range switch at 50.

23. Apply a 700 cycle per second signal and adjust the signal generator output attenuator for an amplitude meter indication of exactly 9/10 of full scale.

24. Switch the Filter-Osc. Selector to IN.

25. Turn the Filter Osc. Tuning dial to 42,000 cpm while watching the Amplitude Meter. At approximately 42,000 cpm a peak meter indication of 9/10 full scale will be observed, as was the case at the OUT position (Step 23).

26. If the IN and OUT meter indications are not exactly the same; adjust the Filter Adjustment control until correlation is attained.

27. Set the Filter-Osc. Selector switch at OUT.

28. Set the Frequency Range switch at 150.

29. Apply a 2000 cycle per second signal and adjust the

signal generator output attenuator for an amplitude meter indication of exactly 9/10 of full scale.

30. Switch the Filter-Osc. Selector to IN.

31. Turn the Filter-Osc. tuning dial to 120,000 cpm while watching the Amplitude Meter. At approximately 42,000 cpm a peak meter indication of 9/10 full scale will be observed, as was the case at the OUT position (Step 29).

32. If the In and OUT meter indications are not exactly the same; adjust the Filter Adjustment Control until correlation is attained.

F. System Calibration - Analyzer and Pickup

Optimum accuracy of vibration analysis will be achieved only if the Analyzer is calibrated in accordance with the characteristics of the Vibration Pickup that will ultimately be used in the system.

1. The method described below includes the use of a signal generator which is adjusted to simulate the pickup signal at a given frequency and load. This signal is then applied to the input of the Analyzer and the Overall Gain Control is adjusted to read the displacement (double amplitude) corresponding to that pickup signal output. This method affords a rapid pickup-instrument calibration and in most cases, will be satisfactory. Before this calibration can be performed the pickup sensitivity must be known. The exact sensitivity of the Model 544 Pickup with Serial Number Prefix "c" and on is indicated by the last three digits of the serial number. This information can be supplied in most cases, by INTERNATIONAL RESEARCH AND DEVELOPMENT CORPORATION in the form of MVRMS/100CPS/.001 IN. P-P. Always include the Pickup Model Number e.g. 544 or 545 and the <u>complete</u> serial number when requesting this information.

This procedure for calibrating the Model 600B Overall Gain is as follows:

A. Connect the oscillator to the input of the analyzer.

B. Connect the VTVM to the oscillator terminals.

C. Set the Filter-Osc. Selector at the OUT position.

D. Set the Mils-In/Sec switch at the 1 mil position.

E. Set the Disp-Vel switch at Disp.

F. Adjust the oscillator frequency to 100 cps and the output attenuator to indicate the pickup output in MVRMS at 100 cps at .001 IN. P-P on the VTVM.

G. Adjust the Overall Gain Control until the Amplitude Meter indicates exactly Full Scale. This control is located on the large printed circuit board, between the vertical mounted boards and toward the front.

G. Test Signal Adjustment

The Test Signal is used as a self check feature of the instrument. The calibration of the Test Signal should be performed after all preceding calibration, adjustments and completes the calibration of the Model 600.

1. Set the Mils-In/Sec switch at the Test Position.

2. Set the Frequency Range switch at 5.

3. Set the Disp-Vel switch at Disp.

4. The Amplitude Meter should now indicate HALF SCALE.

5. If the Amplitude Meter indication is incorrect, adjust the Test Signal Adjustment control until this reading is attained. This control is located on the large printed circuit board and is between the two vertical boards on the extreme right.

6. The Frequency Meter should now read 3600 cycles per minute. If not, adjust the Frequency Meter Adjustment control until

this reading is attained.

NOTE: The 3600 cpm reading is representative of the 60 cycle line frequency. In areas where 50 cycle line frequency is used the frequency meter should read 3000 cpm.

TEST EQUIPMENT

The following test equipment, or its equivalent, is required to perform the calibrations described in the preceding pages.

1. AC-VTVM - Ballantine Model 302C 3% accuracy
2. Audio Oscillator - Hewlett Packard Model 200 CD

   Frequency Range: 5 cps to 5 kcps 2% dial accuracy
3. Synchronous Motor - 1800 cpm
4. Additional accessories
   a. AN3106B-10SL-4S connector - IRD Part No. 1189
   b. 5/16" spin-tight
   c. 1/2" spin-tight
   d. Screwdriver - insulated blade

MAINTENANCE SERVICE

Periodic checks should be made to determine whether any dust or debris has accumulated in the instrument. Particular attention should be given to the connectors which receive the vertical plug-in circuit boards.

The SCHEMATIC (Dwg. #600-134) is arranged to correspond as much as possible to the physical elements of the analyzer section of the instrument. The printed boards, for example, correspond to the schematic areas outlined and identified by number. Comparison of the tube requirements with the TUBE LAYOUT completes the association of the electronic circuitry with the physical layout.

VOLTAGE AND RESISTANCE MEASUREMENTS (Sec. 5-3) presented as a service aid were taken with an RCA Senior Voltohymst. All measurements were made to chassis ground. Readings should be made on the most sensitive scale possible to minimize error.

Control settings required when making these measurements are as follows:

Control	Position
MILS INS/SEC	TEST
FILTER-OSC SELECTOR	OUT

Control	Position
DISP. VEL.	DISP.
FILTER-OSC TUNING	ANY
FREQUENCY RANGE CPS	5
AMPLITUDE METER	.5 (of full scale)
FREQUENCY METER	3600

CAUTION: When checking voltages on tubes V11, V12, and V13 when using an adaptor under the tube, do not pull the tube with power ON.

VOLTAGE AND RESISTANCE MEASUREMENTS

5-3 ALL DC VOLTAGES TAKEN TO CHASSIS GROUND WITH RCA VTVM, STROB FIRING AND MILS/IN/SEC SWITCH AT TEST POSITION, FILTER-OSC SWITCH IN OUT POSITION.

600-82 BOARD								
Pin No.	V1-ECC83		V2-7308		V3-6072		V4-5814A	
	Resis-tance	Volts Zero Sig	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.
1	260K	109VDC	Inf.	42 VDC	260K	74 VDC	260K	87VDC
2	33K	-.1VDC	1 Meg.	0	1.1 Meg.	8 VDC	2.7 Meg.	1.75
3	1.5K	.8VDC	3.3	2VDC	14K	10.5VDC	1.5K	3.2VDC
4	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC	26K	19VDC VAC	26K	19VDC 2.6VAC
5	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC	26K	19VDC VAC	26K	19VDC 2.6VAC
6	300K	100VAC	160K	170VDC	35K	240VDC	33K	240VDC
7	1.1Meg.	-.15VDC	630K	35.5VDC	1.05Meg.	35VDC	290K	74VDC
8	1.5K	.76VDC	Inf.	42 VDC	24K	63.5VDC	22K	82VDC
9	26K	19VDC 3.3VAC	0	19VDC 3.3VAC	26K	19VDC 3.3VAC	26K	19VDC 3.3VAC

600-15 BOARD								
Pin No.	V5-5751		V6-5751		V7-6072		V8-5751	
	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.
1	340K	150VDC	100K	205VDC	33K	240VDC	540K	120VDC
2	3.3Meg.	11VDC	250K	59VDC	1.1Meg.	38VDC	0	2.7
3	82K	42.5VDC	33K	70VDC	130K	76VDC	2.7K	4.6VDC
4	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC
5	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC	26K	19VDC 2.6VAC
6	134K	210VDC	68K	190VDC	55K	208VDC	33K	240VDC
7	630K	27VDC	2.0Meg.	58VDC	1.6Meg.	12	550K	120VDC
8	82K	42.5VDC	33K	70VDC	4.7K	18.5VDC	34.2K	120VDC
9	26K	19VDC 3.3VAC	26K	19VDC 3.3VAC	26K	19VDC 3.3VAC	26K	19VDC 3.3VAC

600-14 BOARD								
	V9-5726		V10-5727		V11-ECC83		V12-5651	
Pin No.	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.	Resis-tance	Volts Zero Sig.
1	360K	4.6VAC	1.1Meg.	.11	1.3Meg.	222VDC	100K	85VDC
2	360K	4.6VAC	6.8K	11VDC	74K	148VDC	0	0
3	26K	19VDC	26K	19VDC	Inf.	150VDC	100K	85VDC
4		2.6VAC		2.6VAC	26K	19VDC	0	0
	26K	19VDC	26K	19VDC		2.6VAC		
5		3.3VAC		3.3VAC	26K	19VDC	100K	85VDC
	68K	10VDC	6.8K	11VDC		2.6VAC		
6	0	0	100K	175VDC	Inf.	150VDC	0	0
7	0	0	6.8K	11VDC	64K	84VDC	0	0
8	X	X	X	X	100K	85VDC	X	X
9	X	X	X	X	26K	19VDC		
						3.3VAC	X	X

BASEBOARD		
	V13-6L6GB	
Pin No.	Resis-tance	Volts Zero Sig.
1	Inf.	0
2	33K	240VDC
3	300K	600VDC
	3 Meg.	400 VDC
4		
	1.5 Meg.	220VDC
5		
6	Inf.	0
7	33K	240VDC
8	33K	240VDC
9	X	X

7 - SPARE PARTS LIST

The following is an itemized listing of the parts which most probably are subject to field replacement. For that reason, they comprise the recommended spare parts list for general service of the instrument.

Part Description	IRD Part No.	Manufacturer
Power Cord	2501	
Grounding Extension Plug	1222	
Pointer Knob (gray)	1242	Raytheon #70-5-2G
Round Knob (gray) Large	1244	Raytheon #125-2-2G
Tuning Dial Glass	1134	
Amplitude Meter 4-1/2 Inch Lighted, Custom Chrome IMA Meter	3555	Simpson
Lighted, Custom Chrome IMA Meter Meter 4-1/2 Inch Frequency	3554	Simpson
Silicon Rectifier (four)	3477	Diodes Incorp DI510
Dial Lamp	1526	General Electric #47
Dial Lamp (Meters)	4365	General Electric #51
Tube Shield 1-15/16 Inch	1806	Cinch Jones 9S2
Spring, Dial, Drive Type 3	1021	Walsco Electronics
Fuse, Extractor, Miniature 3AG	1516	Littelfuse
Cable, Dial, Phosphor-Bronze 30-1/2 Inch Long	2353	Walsco Electronics

RESISTORS

(Unless otherwise specified, all fixed composition resistors are 1/2W, Tolerance ±5%)

Circuit Symbol	Description/IRD Part No.	
R1	1 Meg.	1614
R2	220K	1609
R3	1.5K	1589
R4	1 Meg.	1614
R5	1.5K	1589
R6	33K	1600
R7	220K	1609
R8	3.6 Meg., ±1% Carbon film	2996
R9	750K, ±1%., Carbon film	1574
R10	120K	1606
R11	10K	1596
R12	3.3K	1592
R13	1 Meg.	1614
R14	330K, 2W	3098
R15	1 Meg., ±1% Carbon Film	1578
R16	8.2K	1595
R17	820	3317
R18	220K	1609
R19	1 Meg.	1614
R20	1.2K	1588
R21	22K	1591
R22	82K	1603
R23	150K	1607

Circuit Symbol	Description/IRD Part No.
R24	2.2 Meg. 1591
R25	330K 1610
R26	1.5K 1589
R27	68K,±1% Carbon Film 1566
R28	22K,±1%,Carbon Film 1563
R29	6.8K,±1%,Carbon Film 1555
R30	2.2K,±1%,Carbon Film 1551
R31	680, ±1%,Carbon Film 1545
R32	220, ±1%,Carbon Film 1544
R33	100, ±1%,Carbon Film 1543
R22A	150K 1607
R34	250K, Miniature Potentiometer 1265
R35	15 K Potentiometer 3485
R36	1 K Potentiometer 1282
R37	360K,±1%,Carbon Film 1573
R38	2.2 Meg. 1591
R39	0.5 Meg.,Potentiometer 1288
R40	4.7 Meg. 1621
R41	330K 1610
R42	3.3 Meg. 1620
R43	82K 1603
R44	750K 1613
R45	620K 1612
R46	10K 1596
R47	91K 1604
R48	910K,±1%,Carbon Film 1577
R49	330K,±1%,Carbon Film 1572
R50	68K 1602
R51	33K1% 1564
R52	1.8 Meg. 1590
R53	33K 1610
R54	1 Meg. 1614
R55	6.8K 1594
R56	120K 1608
R57	2 Meg. 1617

Circuit Symbol	Description/IRD Part No.
R58	470K 1611
R59	22K 1598
R60	82K,1W 1646
R61	100 Ohm 1584
R62	4.7K 1593
*R63	1 Meg. 1614
R65	1500 1589
R66	1200 1588
R67	47K,ohm,1W 1644
R68	33K 1600
R69	1K 1587
R70	(
R71	(2K Freq.Adj.Miniature
R72	(Potentiometers
R73	(4517
R74	(
R75	470 1586
R76	6.8K 1594
R77	6.8K 1594
R78	1K 1587
R79	6.8K 1594
R80	6.8K 1594
R81	100K 1605
*R64	470K 1611
R82	1M 1614
R83	6.8K 1W,5% 1635
R84	68K,1W 1645
R85	330K 1W,5% 1656
R86	15K,25W,10% 1731
R87	1M 1614
R88	1M 1614
R89	8.2K 1595
R90	8.2K 1595
R91	2 Meg.,±1% 1581
R92	68K 1602
R93	68K,2W 1718
R94	3.3M 1620
R95	33K,±1% 1564
R96	(100K,WW Potentiometer)
R97	(100K,WW Potentiometer)1253
R100	(50K,WW Poteniometer)
R98	33K,±1% 1564
R99	13K,1% 5168
R101	(
R102	(5K, Potentiometers
R103	(4516
R104	(
R105	(

Circuit Symbol	Description/IRD Part No.
R106	330K 1610
R107	27K 1599
R108	150,2W 1717
R109	100K 1605
R110	68K 1602
R111	91K 1604
R112	68K,1W 1645
R113	100 Ohm Potentiometer 1584
R114	12K,±1% 2906
R115	10K,±1% 1559
R116	47 , 1W, 5% 4310

CAPACITORS

(Unless otherwise specified, all capacitors are 200 VDC)

C1	.15 mf,Paper,mylar 1425
C2	.15 mf,Paper,mylar 1425
C3	.5 mf 2273
C4	500 mfd,15V 5323
C5	.22 mf,Mylar 1424
C6	.15 mf,Paper 1425
C7	50 mmf,Mica,500 VDC 1471
C8	.68 mf,Mylar,Paper 1448
C9	.01 mf 300V Mica 1445
C10	(40 mf,300VDC,Electrolytic)
C11	(40 mf,300VDC,Electrolytic)
C22	(80 mf,300VDC,Electrolytic)
	(Part No. 1304-1305)
C12	0.22 mf,Mylar 1424
C13	5 mmf Mica, 500VDC 1472
C14	50 mmf Mica,500VDC 1471
C15	(
C16	(Specific Values in Assy.
C17	(#600-11
C18	(Part No. 1117
C19	(
C20	0.1 mf,400VDC,Mylar 1433
C21	.22 mf,Mylar 1424
C21A	100 mfd,150V 1487
C21B	100 mfd,150V 1487
C23	.22 mf,Mylar 1424

Circuit Symbol	Description/IRD Part No.
C24	200 mf, 15V Electrolytic 3533
C25	20 mf,150V,Electrolytic 1480
C26	250 mf,25V,Electrolytic 1491
C27	No longer used
C28	.0047 mf,400VDC,Mylar 1453
C29	.047 mf,400VDC,Mylar 1434
C30	20 mf,475V,Electrolytic 1307
C31	.001 mfd,Mica,500VDC 1466
C32	100 mf,12VDC Elect. 1484
C33	2 mf,600VDC 1298
C34	( )
C35	(20 mf,475VDC,Electrolytic)
C36	(1307)
C37	2 mf,600VDC, Oil 1298
C38-C52	Capacitor Assy,#600-10, Selected Values Part No. 1116
C53	.22 mf, Mylar 1424
C54	.25 mf,600VDC,Paper 1439
C55	0.1 mf,400VDC,Mylar 1438
C56	.047 mf,400VDC,Mylar 1434
C57	.1 mf,400 VDC,Mylar 1433
C58	100 mmf Mica 500 VDC 1469

TUBES

(Unless otherwise specified, all tubes are General Electric Five Star or equivalent).

V1	(ECC83-Amperex 1386
V2	(7308 3998
V3	(6072 1409
V4	(5814A 1408
V5	(5751 1407
V6	(5751 1407
V7	(6072 1409
V8	(5751 1407

Circuit Symbol	Description/IRD Part No.	
V9	(5726	1405
V10	(5727	1406
V11	(ECC83-Amperex	1386
V12	(5651	1404
V13	6L6-GB	1395

MISCELLANEOUS

Dial Lights (2) GE #47 1526
Fuses (1), 1-1/2 Amp. Slo-Blo 3 AG 1 littelfuse 1508
Strob Jack (1) 3872

DC Recorder (1) Amphenol #80-PC2F 1219
Scope Jack (1) Amphenol #80C 1822

Meters (2) 1 Ma Movement
A (1) Amplitude = #600-8 Part No. 3555
B (1) Frequency = #600-9 Part No. 3554

110VAC (1) Outlet, Amphenol #61F 1810
(1) Inlet,Hubbell #7486 1814
Pickup (1) Amphenol AN3102A-10SL-4P 1179
Fuse Holder (2) Littelfuse,#342012 1516

Circuit Symbol	Description/IRD Part No.	
D1	International 3AS1	1376
D2	International 3AS1	1376
D3	Raytheon IN459A	4919
D4	Raytheon IN459A	4919
D5	(	3477
D6	(Diodes Inc DI510	3477
D7	(	3477
D8	(	3477
D9	Raytheon IN67	1380
D10	Raytheon IN67	1380
D11	Raytheon IN67	1380
D12	Raytheon IN67	1380
K1	SPDT, 10K ohm 100MW Relay	4666
T1	Power Transformer	3749
CH1	16 HY-50MA Choke	2342

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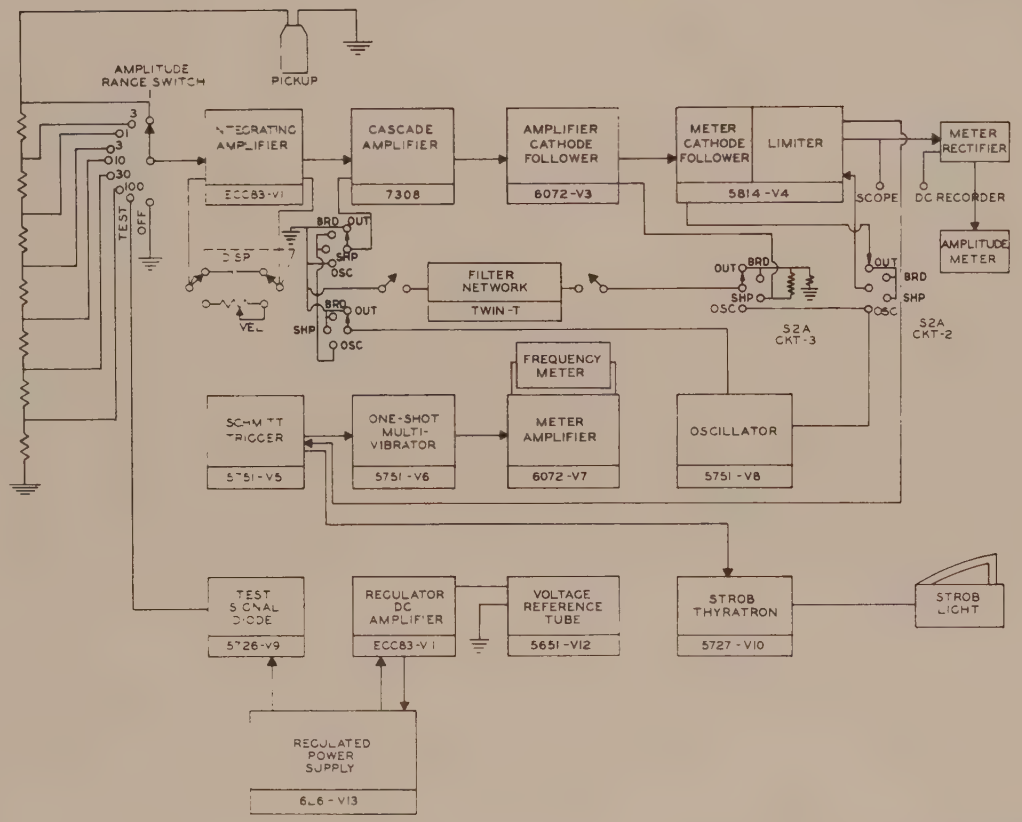
C6-0241	



INTERNATIONAL RESEARCH AND DEVELOPMENT CORPORATION, COLUMBUS OHIO	DRAWING REVISION		DATE
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		APP BY Ron Wright	
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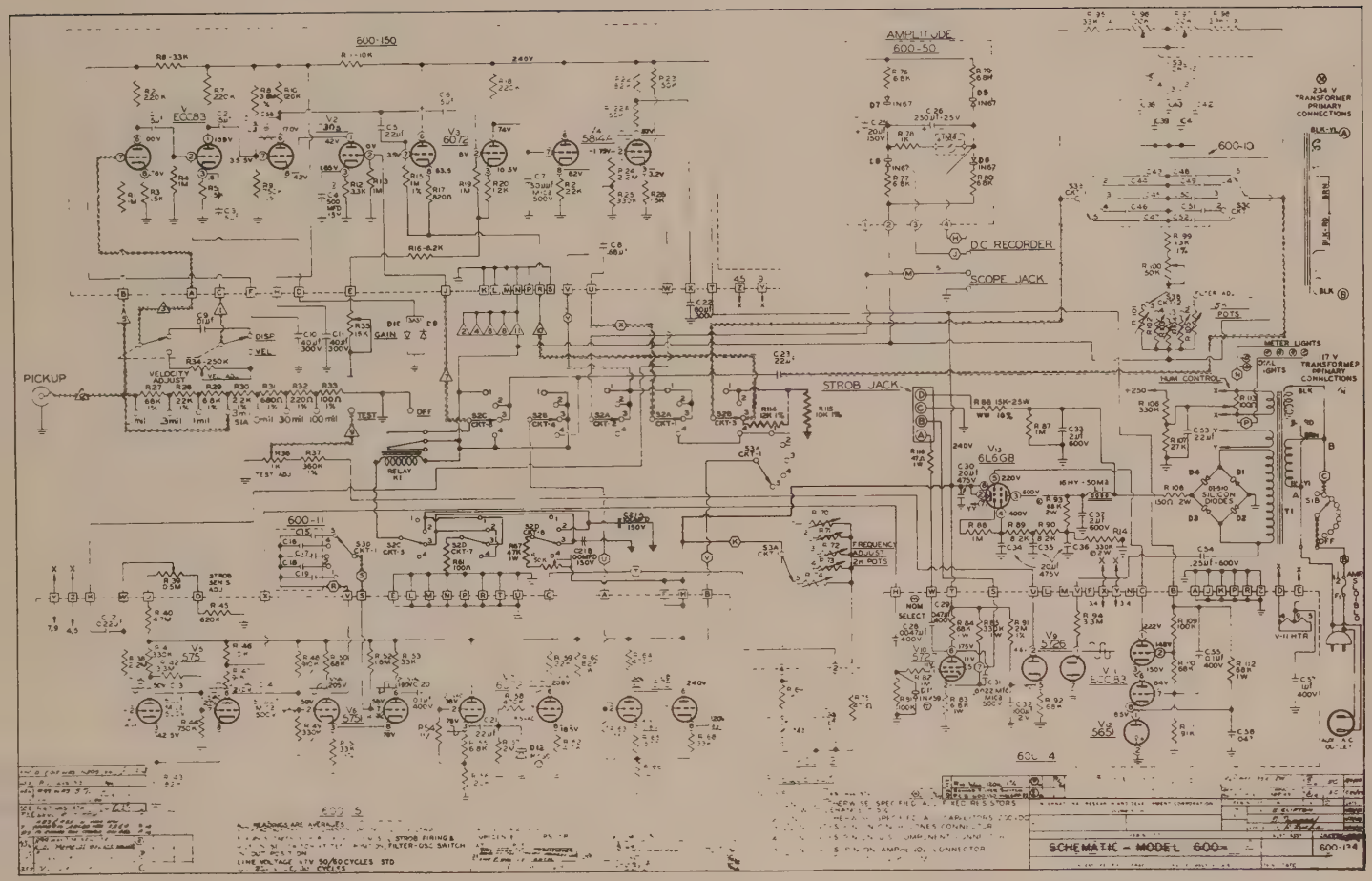
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600-50
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600-4
600-5
PICKUP
DISP
VEL
VELOCITY ADJUST
GAIN
TEST
OFF
RELAY K1
STROB JACK
DC RECORDER
SCOPE JACK
FREQUENCY ADJUST 2K POTS
METER LIGHTS
DIAL LIGHTS
HUM CONTROL
SILICON DIODES
117 V TRANSFORMER PRIMARY CONNECTIONS
234 V TRANSFORMER PRIMARY CONNECTIONS
V-H HTR
SCHEMATIC - MODEL 600
600-134

APPENDIX B

GENERAL PERFORMANCE SPECIFICATIONS
IRD MODEL 600 VIBRATION ANALYZER

The Model 600 Vibration Analyzer is a rugged portable instrument designed for the precise measurement and analysis of vibration, for portable in-place dynamic balancing and for production balancing of rotating machines. Included with the instrument are the following accessories:

1. IRD Model 544 Vibration Pickup (See Note 1)
2. 12-foot Pickup Cable
3. Pickup Extension Probe
4. IRD Model 566 Stroboscopic Lamp
5. 12-foot Strob Cable
6. 4-foot Power Cable with Adaptor
7. IRD Model 600 Vibration Analyzer Operation and Maintenance Manual
8. National Training Program (See Note 2)

Amplitude meter and associated switches are provided to measure vibration in terms of displacement or velocity, as sensed with vibration pickup. The available full-scale ranges are:

Amplitude	Velocity
0.1 mil	.03 in/sec
0.3 mil	0.1 in/sec
1.0 mil	0.3 in/sec
3.0 mils	1.0 in/sec
10.0 mils	3.0 in/sec
30.0 mils	10.0 in/sec
100.0 mils	30.0 in/sec

(1.0 mil = .001")

A variable frequency filter is included to aid in eliminating all but the selected vibration frequency in performing vibration analysis and dynamic balancing. The filter can be adjusted throughout the range of 450 cpm to 150,000 cpm through the use of a tuning adjustment and an associated range switch. The filter has three (3) selectivity characteristics, with the frequency response for each position as follows:

OUT:

No filtering is performed on the vibration signal and the analyzer acts as a broad band amplifier having a frequency linearity or response of $\pm$3% of the full-scale as indicated on the amplitude meter over the specified frequency range.

BROAD:

Constant percentage band-width at 3 db down points Q=10 10% maximum
7% minimum

Rejection curve slope at 3 db down points: 60 db per octave minimum
Ultimate attenuation one octave removed from the tuned frequency: 22 db minimum

SHARP:

Constant percentage band-width at 3 db down points: Q=20 5% maximum
3.5% minimum

Rejection curve slope at 3 db down points: 90 db per octave minimum
Ultimate attenuation one octave removed from tuned frequency: 30 db minimum

A frequency meter is included to indicate predominant frequency of the vibration being measured. The following frequency ranges are selected by means of a frequency range switch and are applicable to either displacement or velocity measurement:

0 to 1,500 cpm
0 to 5,000 cpm
0 to 15,000 cpm
0 to 50,000 cpm
0 to 150,000 cpm

The stroboscopic lamp flash is automatically synchronized with the frequency of vibration. The lamp is housed in a lantern type case and a white stroboscopic bulb is used for maximum visibility.

An internal oscillator is provided so that the stroboscopic lamp can be used for measurement of rotating speed or for the slow-motion observation of rotating components. The flash rate can be manually adjusted from 450 flashes per minute to approximately 5,000 flashes per minute. When the Filter Oscillator Selector is switched to either the Broad or Sharp position, the filter will be peaked to within $\pm$.25% of the frequency to which the internal oscillator is tuned.

An output jack, for oscilloscope analysis is provided. The vibration waveform can be viewed for overall vibration by bypassing the variable frequency filter, or the vibration waveform for any frequency can be viewed by tuning the variable frequency filter to that frequency.

Ruggedized opaque vacuum tubes are used for stability and long service life.

A compartment is built into the cabinet for accessory storage.

The panel cover is detachable and serves as a console support for resting the console at an angle at approximately 30°. This facilitates the use of the analyzer while resting on the floor.

Panel color-coding is used to identify the proper relationship between the various ranges and related switch positions.

Overload Signal -- The analyzer is capable of recovering from a signal input corresponding to 10 times the full-scale reading of the amplitude meter and of any duration within 3 seconds maximum after removal of the overload signal.

Switching Transient Recovery Time -- When switching to the Broad or Sharp position of the Filter Oscillator Selector from any other position of that switch, the transient recovery time does not exceed 3 seconds.

No Signal Indication -- With no signal applied to the input of the analyzer and the amplitude range switch at the most sensitive position, the amplitude meter indication is not greater than 3% of full-scale.

Line Fluctuation -- With a given signal input the amplitude and frequency meter indications do not change more than $\pm$2% with variations of $\pm$10% of the 117 volt power line voltage.

Strob Sensitivity -- There is no erratic firing of the strob light when signal is 8% of more of the full-scale indication on the amplitude meter.

Phase Shift with Amplitude -- With a given signal input to the instrument, the strob pulse, as referenced to the input signal, does not change more than $\pm 8^{\circ}$ with signal amplitude changes between 30% and 100% of full-scale on any position of the amplitude range switch.

Scaling -- The strob circuitry is designed so that with vibration signal frequencies higher than approximately 85 cps, automatic division takes place. As a result, even and odd sub-multiple firing pulses are available at the strob output jack consistent with strob bulb life characteristics and maintaining firing rate synchronization with the vibration signal frequency.

Power Consumption -- The power consumption of the complete instrument with signal applied to the input and with strob firing does not exceed 90 watts.

Impedances -- The input and output impedances of the instrument are as follows:

a.	Pickup Input:	100,000 ohms
b.	Recorder Output:	1,000 ohms
c.	Oscilloscope Output:	800 ohms

Recorder Jack Output -- The instrument provides a DC voltage for external recording purposes through the DC recorder jack. This voltage is 1.1 volts minimum DC with full-scale indication on the amplitude meter and remains constant within ±3% of the operating frequency spectrum.

Frequency Meter Linearity -- Frequency meter linearity is ±2% of full-scale indication over the entire operating frequency range of the instrument.

Filter Oscillator Tuning Dial -- This indication is within ±5% of the actual frequency at which the instrument is tuned.

NOTE 2

The IRD Audio-Visual Training School scheduled in the Continental boundaries of the United States on a monthly basis in each sales district permits the employees of the purchaser to attend this school nearest their base. The maximum number of student for any session is 25. This permits individualized analyzing and balancing instruction. Each student receives a copy of the IRD Vibration Analysis & Dynamic Balancing Instruction Manual.

Additional personnel for future training may be negotiated by the purchaser based upon the standard training schedule, where and when available.

Broad-Sharp filter information contained herein applies to all instruments, IRD Model 600, Serial No. 395 up.

NOTE 1

IRD Model 544 Vibration Pickup

The IRD Model 544 Vibration Pickup is provided as standard equipment with all IRD vibration measurement, analysis and monitoring instruments. It is the most rugged and sensitive pickup of its type. Hand held or mounted on a machine it can be used in any position without affecting the readings. The pickup is a seismic velocity type consisting of a moving coil in a permanent magnetic field. The voltage output is directly proportional to the case velocity in the direction parallel to the pickup axis.

1. Sensitivity: 240 Millivolts RMS ± 10% for .001" peak-to-peak displacement @ 100 cps corresponding to a velocity constant of 1.08 volts peak per inch per second. Sensitivity is unaffected by orientation.

2. Orientation: May be used in any mounting position without adjustment or correction.

3. Frequency Response: Room ambient (±77°F.) ±8% over the frequency range 12-1000 cps. Down 8% ±13% @ 10 cps. Pickup frequency response drops exponentially at lower frequencies. Elevated ambient (+250°F.) ±13% over the frequency range 12-1000 cps. The above limits are total variations for any mounting position of the pickup.

4. Natural Resonant Frequency: 16 cps critically damped at +77°F.

5. Temperature Range: -40°F. to 500°F.

6. Impedance: Approximately 2,000 ohms D.C. resistance.

7. Amplitude Range:

Minimum:	Limited only by amplifier gain and noise level.
Maximum:	.125 inches peak-to-peak up to 70 cps; above 70 cps - maximum shake 25 g's.
Transverse Response	Average Response less than 5% over the frequency range 10-1000 cps.

8. Amplitude Linearities: ±5% from .0001 to .1000 inches peak-to-peak displacement.

9. Weight and Dimensions: 4-7/8" H x 2-3/16" dia. - 21 ounces.

10. Connector: Equivalent to 732S-10SL-4P.

11. Accessory Equipment Available at Additional Cost: Magnetic Pickup Holder; Magnetic Shield Assembly; Shaft Stick; Extension Probe; Vise Grip Pickup Mount; Pickup Cables - 4', 12', 25', and 50' length in standard cable, standard cable with waterproof connectors, and high-temperature (500°F.) cable.

12. Damping Characteristic: The pickup has a damping factor of approximately .7 which results in essentially flat operation over the frequency range. This provides improved accuracy and improved transient response for low frequency operation.

13. Power Required: The pickup is a self-generating unit and requires no external power source.

14. Mounting: One 1/4" - 28 x 1/4" tapped hole for mounting to suitable bracket. May be hand-held for probing studies.

15. Recommended Max. Acceleration: 5 g's at 20 cps to 30 g's above 50 cps, continuous.

16. Construction: High-Temperature Solder Connections
Case - Machined Aluminum

17. Magnetic Field Sensitivity:

Without Shielding	.15 in/sec/gauss
With 10:1 Shielding (IRD Part #1157)	.015 in/sec/gauss
With 100:1 Shielding (IRD Part #3563)	.0015 in/sec/gauss*

*.0015 in/sec/gauss provides less than 25% up-scale reading on most sensitive instrument amplitude range scale for Model 600, 601, 330, and 314 Vibration Analyzers.

18. Waterproof: Pickup case and connector are watertight. Pickup performance is unaffected by humidity, condensation and immersion in water for short periods.